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Description

This invention relates to a hydrocarbon cracking furnace and to a hydrocarbon cracking method using said cracking furnace.

Thermal cracking of hydrocarbons is a technique which is practised widely in the hydrocarbon industry, and numerous configurations of thermal cracking furnaces have been proposed. For example, European Patent Specification No. 0074435 discloses a form of thermal cracking furnace in which a mixture of hydrocarbon and superheated steam is caused to flow through a reactor conduit, cocurrent with a flow of a heating gas surrounding the conduit.

As is disclosed in EP-B-0074435, certain characteristics are particularly desirable for the thermal cracking of hydrocarbons. In particular, high reaction temperatures, facilitating short residence times will in general increase the yield of the desired products of thermal cracking, whilst minimizing the production of by-products.

It is therefore desirable that a thermal cracking reactor should be as short as possible, but should nevertheless provide for the maximum heat transfer over its length.

U.S.-A-4412975 discloses a form of thermal cracking reactor in which a tube containing the hydrocarbon to be cracked passes through a radiant enclosure, in which the tube is heated by radiation from the furnace walls. This system, like that disclosed in EP-B-0074435, suffers from the disadvantage that because the flue gases cool as they pass through the furnace, the temperature of the heat transfer surface of the heat exchanger varies along the length of the furnace. Thus, it is not possible to maintain the heat transfer surface at the optimum temperature for maximum heat transfer, along the whole of its length.

The factor which limits the heat transfer characteristics of a tubular cracking reactor, of the kind disclosed in EP-B-0074434 and US-A-4412975 will in general be the thermal failure temperature of the tubular reactor, which will generally be metallic. Thus, in the furnace of Figure 2 of US-A-4412975, if the reactor tube is close to its thermal failure temperature in the region adjacent the burners, it will be at a temperature substantially lower than this at a point downstream of the burners.

U.S.-A-4412975 discloses various attempts to overcome this difficulty, by means of back-mixing of flue gases, and (in the discussion of prior art), the provision of multiple burners. Such attempts have met with only limited success, because a substantial temperature gradient along the length of the reactor still results, and the temperature of the existing flue gases is relatively high, leading to poor fuel economy.

In accordance with the present invention, there is provided a hydrocarbon cracking furnace (1), comprising at least one cracking reactor (8) having a first tube (14), connected to a feedstock inlet, said tube being open-ended downstream and being disposed substantially coaxially within a second tube (12), connected to an outlet for cracked products and closed proximate and around the open end of said first tube, said first and second tubes communicating at a first end (15) of the reactor, a burner (3) disposed proximate the said first end of the reactor, and orientated to generate a flow of hot flue gas in a flue gas duct (10) around the second tube, in a direction co-current with the flow of feedstock in an inner duct (11) defined by the annular space between the first and the second tubes, the said first end (15) of the reactor being disposed in the flow of flue gases from the burner (3), and the reactor extending downstream with respect to the flow of flue gases from the said first end.

This arrangement is particularly advantageous, because radiative heat transfer from the outer tube wall (i.e. the outer surface of the inner duct) to the inner tube wall takes place very readily through the fluid to be heated (e.g. the steam/hydrocarbon mixture). Thus, the inner tube surface is heated to a temperature in excess of that of the surrounding fluid. Not only does this serve to pre-heat the incoming fluid in the inner tube, it also provides additional heating to fluid in the space between the inner and outer tubes by radiative transfer from the inner tube.

The internal surface of the outer of the two coaxial tubes, which is responsible for heat exchange with fluid in the inner duct, can be maintained at a substantially constant temperature, along substantially the whole of its length, even though the temperature of the fluid within it is increasing, and the temperature of the surrounding flue gas is decreasing, by providing a continuous change in the heat exchange characteristics of the outer duct along its length as referred to above. Furthermore, the outer wall of the inner duct, which is generally a metallic tube, can be operated very close to its thermal failure temperature, along substantially the whole of its length, thus providing the maximum heat transfer.

The means defining the outer surface of the outer duct is preferably formed of a ceramic material (which term as used herein includes within its scope refractory materials of various kinds capable of withstanding the high temperature involved), since the temperature of operation of the outer duct will in general be substantially higher than that of the inner duct.

The cross section of the outer duct preferably varies along at least a portion of its length in such

a manner as to provide in use an inwardly directed radiative heat flux from the said outer wall which varies along the said portion of the length of the outer duct, in such a way as to tend to compensate for fall in temperatures in fluid flowing in the outer duct.

The variation in cross-section of the outer duct may take the form of a variation (normally a decrease) in cross-sectional area of the duct, and/or an increase, preferably a continuous increase, in the surface area per unit length of the outer wall of the outer duct.

The construction is preferably such that, when flue gas from a burner at or adjacent an end of the inner duct is drawn through the outer duct, the heat transfer characteristics of the said outer wall of the outer duct are such as to cause the temperature of the surface of the outer wall of the inner duct over a portion of its length corresponding to the said portion of the outer duct to be substantially constant in use.

The said portion of the length of the duct over which the cross-section varies is preferably at least one quarter, more preferably at least one half, more preferably still at least three quarters, and most preferably substantially all of the length of the duct.

The change in cross section of the outer duct tends to compensate for the fall in temperature of the flue gases as they flow through the outer duct. Thus, the temperature of the flue gases may fall along the duct in a typical embodiment from about 2000°C at the burner end to about 1500°C at the exhaust end. By varying the outer duct cross section as indicated, it is possible to maintain the outer wall temperature sufficiently high to provide the desired level of radiative heating to the inner duct. Typically, the temperature of the outer duct wall in a cracking furnace in accordance with the invention may vary from 1600°C at the burner end to 1200°C at the exhaust end, preferably from 1500°C at the burner end to 1450°C at the exhaust end.

The particular temperature utilised will vary from installation to installation, depending not only on the geometry of the system, but also on the cracking reaction which it is desired to carry out.

The particular temperature profile utilised for the outer wall of the outer duct is preferably chosen so as to maintain the temperature of the wall of the inner duct which is in contact with the material to be cracked at at least 950°C, over a substantial part of its length.

The temperature of the inner wall of the outer duct is preferably as high as possible, typically greater than 1070°C, and as high as material limitations permit, over a substantial part of its length.

Clearly some heat will be transferred to the inner duct by radiative and convective transfer from the flue gases. In a typical embodiment however, at least 60%, preferably at least 75% of the heat transfer to the inner duct will be by radiative transfer from the outer duct wall.

The surface area per unit length may be increased by providing on the inner surface of the outer duct a plurality of ribs, having a cross sectional area which increases continuously along the said portion of the outer duct.

The increase in surface area over the said region may preferably be continuous, for example by providing ribs having a cross sectional area which increases continuously, as described above, However, the increase in surface area may, less preferably, be achieved by means of a number of small stepwise changes in the shape of the cross section of the outer duct, for example by constructing the outer duct from a plurality of blocks, joined along the length of the duct, each having a slightly increased internal area per unit length.

The cross sectional area of the outer duct preferably decreases over its length or preferably at least over the said portion of its length. This has the effect of increasing the velocity of the gas flow in the space between the inner and outer ducts, and thus increasing convective heat transfer between the gas and the wall of the outer duct. The said decrease in cross sectional area may be achieved by providing the said ribs of increasing size as described above. Alternatively, or additionally, the decrease in cross sectional area may result from a stepwise or continuous decrease in diameter of the outer duct.

Raised ribs may be provided along the whole or part of the length of the outer wall of the outer duct, so as to provide the desired variation in surface area and in cross-section. Both the size and number of such ribs may be increased, over the length of the outer duct.

The outer surface of the duct is preferably formed by moulding a ceramic material, for example by moulding a ceramic material around a disposable former, having the desired number of ribs on the outer surface thereof. The disposable former may be made of a foamed plastics material, for example polystyrene. After the ceramic has been allowed to set, the disposable former may be removed, by dissolution with a solvent, or, more preferably, simply by firing the ceramic to a temperature at which the plastics material is pyrolysed.

Several formers are preferably utilised in a single casting operation, to provide a plurality of elongate passageways. In one embodiment of this aspect of the invention, the ceramic casting is from 7.5 to 10 m in length. This method of construction results in low materials cost, and low fabrication costs, and can provide a structure which is sub-

stantially stronger with regard to thermal stresses, as compared with previous constructions.

In an alternative and preferred method, a ceramic material may be cast by a compression moulding technique, for example using a metallic mould. When this method is employed, it is generally necessary to mould the ceramic material defining the outer duct in a number of longitudinal sections, having a maximum length of, for example 1 m or less.

The ceramic material is preferably provided with a plurality of elongate longitudinal grooves extending along the radiative surface thereof. Such elongate grooves have been found to be of substantial benefit in maximising resistance of the ceramic material to thermal shock. The elongate grooves may be for example about 1 cm in depth and 0.5 to 1 mm in width. They may conveniently be formed by drawing toothed comb-like members through the ceramic material before the material is fired.

The two coaxial tubes communicate at one end thereof, that end being located in the region of the heat exchanger occupied by the hottest flue gases. With this arrangement, there is no necessity for the supply of heat exchange fluid to the inner duct to pass through a burner chamber, in which spatial temperature fluctuations may occur. Such temperature fluctuations would again result in the inability to operate the heat exchanger at the limit of temperature of the heat exchange surface of the inner duct.

The particular arrangement of the hydrocarbon cracking furnace in accordance with the invention is advantageous in providing optimum temperature distribution of the reactor tubes, without local "hot spots". The cracking furnace of the invention may preferably, but not essentially, include a heat exchanger.

The thermal cracking furnace in accordance with the invention preferably includes a number of heat exchange tubes arranged in a parallel fashion. Each such heat exchange tube may be provided within a generally hexagonal ceramic block, having a radiative surface area which varies continuously along a portion of its length. Such hexagonal blocks fit conveniently together, and provide the greatest structural integrity, for minimum weight. The heat exchangers may be provided in an array in which tubes are vertically staggered, to facilitate the supply of feedstock to the various heat exchange sections.

It is a particularly advantageous feature of a heat exchanger, having a plurality of flue gas ducts in cast in a ceramic block, that a thermal cracking furnace can be produced which is readily adaptable to the cracking of alternative feedstocks. Different feed stocks will, in general, require different thermal cracking temperatures, and heats of reaction. In a heat exchanger of the kind having raised ribs of varying cross-section, the heat exchange temperatures of the inner duct through which the feed stock is passed can be controlled, by appropriate choice of the size and number of ribs formed on the ceramic material. Accordingly, different ceramic blocks, having different heat exchange characteristics, may be exchanged, within the same thermal cracking furnace, so as to accommodate different feedstocks.

Furthermore the design of the thermal cracking furnace in accordance with the invention is such that an existing furnace may be very easily converted into a furnace in accordance with the invention, simply by providing a ceramic block and tube structure therein.

At least one additional heat exchanger is preferably incorporated to provide rapid cooling of the thermally cracked material, on its exit from the furnace area. Rapid cooling in this way minimizes the production of unwanted by-products. In a preferred embodiment, the additional heat exchanger may be of the co-axial type described above, with high pressure water being supplied to the inner tube, whereby high pressure steam is generated in the outer tube.

A number of embodiments of the various aspects of the invention will now be described with reference to the acommpanying drawings in which:-

Figure 1 is a schematic diagram of a thermal cracking furnace incorporating a heat exchanger in accordance with the invention,

Figure 2 is an enlarged view of one embodiment of an inner duct, and

Figure 3 is schematic sectional end elevation in the direction of arrows 3-3 of part of the furnace of Figure 1.

Referring first to Figure 1 and 2, a furnace for the thermal cracking of hydrocarbons comprises a casing 1, containing an inner layer 2 of an insulating material, which may for example be a ceramic material. A burner 3 is located at one end of the casing 1, and is adapted to burn a suitable hydrocarbon feed material, supplied through line 4. Combustion air for the burner 3 is supplied by a pump 7 through a conduit 6g and is pre-heated in heat exchangers 18a and 18b, and delivered to the vicinity of burner 3 via conduit 6b. Additional heating of this air can be achieved, if desired, by causing it to flow between casing 1 and insulating material 2 en route to burner 3. The hydrocarbon fuel supplied by line 4 may if desired also be heated before passage to burner 3.

The furnace includes a block of eight heat exchangers, of which two are indicated generally at 8 in Figure 1 and which are illustrated in more

detail in Figures 2 and 3. Heat exchangers 8 comprises a ceramic block 9, having disposed therein a duct, again shown schematically at 10 in Figure 1, and in more detail in Figure 2 defined between block 9 and a tube 12, described in more detail below. In practice, a large number of ducts, for example six or eight will typically be utilised.

Figure 3 is a schematic view in the direction of arrows 3-3 in Figure 1, showing the construction of the outer duct of heat exchangers 8 from a plurality of generally hexagonal ceramic blocks 9a to 9h. Blocks 9a to 9h in Figure 3 illustrate the progressive change in cross section of the hexagonal ceramic blocks along their length, as will be described in more detail hereinafter.

Disposed within ducts 10 are inner ducts 11, having three concentric tubes, an outer tube 12, the outer surface of which defines a heat exchange surface with flue gases produced by burner 3, an intermediate tube 13 for supplying the high temperature steam diluent, and an inner tube 14 for supplying feedstock. In Figure 3, ducts 10 are present in each of blocks 9a to 9h, but are illustrated only in block 9a for clarity. The various tubes 12, 13 and 14 meet at end 15 of tube 10.

Flue gases from burner 3 pass through ducts 10 and exchange heat with ceramic block 9. Heat exchange with tubes 12 is primarily by radiation from the inner surface of ceramic blocks 9. After passage over tubes 12, flue gases from burner 3 are directed through heat exchange tower 20. Heat exchange tower 20 includes various heat exchangers, of conventional form, to preheat the hydrocarbon feed, for air preheat, and to preheat steam, for dilution of the hydrocarbon feed. Heat exchange tower 20 may also be used to preheat the fuel for burner 3, as described above.

Specifically, heat exchange tower 20 includes heat exchangers 18a and 18b, for pre-heating the combustion air, as described above. Tower 20 also includes heat exchangers 22a, 22b and 22c for preheating the feed stock to be cracked, fed through line 23. High temperature steam is supplied through line 25, via lines 25a and 25b to heat exchanger 26a, and heat exchanger 26b. The high temperature steam produced in heat exchangers 26a and 26b is fed, together with the heated feedstock, to duct 11. Specifically, (referring to Figure 2) the feed stock is supplied by pipe 14, and super heated steam via pipe 13. When the furnace is used for the thermal cracking of naphtha, the naphtha feed stock is typically supplied to tube 14 at a temperature of approximately 620 °C, and super heated steam to pipe 13 at a temperature of approximately 1100 °C.

Heat exchange tower 20 also includes an additional heat exchange element 28, for preheating boiler feed water, for use in heat exchangers 17.

The structure of the inner ducts 11 is described in more detail, with reference to Figure 2. Figure 2 illustrates an inner duct of the kind shown in Figure 1 in which the hydrocarbon to be cracked, for example naphtha, is supplied via conduit 30 to inner tube 14. Preferably a relatively low amount of dilution steam is added to the hydrocarbon in the convection section. For example the steam dilution ratios employed for the cracking of LPG, naphtha and gasoil are preferably (by weight) 0.3 to 0.6, 0.4 to 0.8, and 0.6 to 1.0 by weight respectively, more preferably about 0.4, 0.5 and 0.8 respectively. Superheated steam is supplied via conduit 31 to the space defined between tubes 14 and 13. Orifices (not shown) may be provided along the length of tube 14, to enable the naphtha feedstock to mix with superheated steam supplied through conduit 31. Whilst contained within the tube 13, the hydrocarbon feed and superheated steam mixture is at a relatively low temperature, and insufficient for substantial thermal cracking to take place. At the end 15 of the duct 11, the hydrocarbon feed/steam mixture passes into the space defined by tube 13, and outer tube 12. Here, heat exchange takes place with the metallic surface of the outer tube 12. Because of the increasing surface area of the inner surface of blocks 9, the temperature of the outer surface of pipe 12 remains substantially constant over that portion of its length for which the radiative area per unit length increases.

The duct 10 in which the tube 12 is located is provided on its inner surface with inwardly projecting ribs as illustrated in more detail with reference to Figure 3.

Figure 3 is a schematic diagram, showing the change in the internal cross-section of the blocks 9 along their length. Four general types of block are illustrated in Figure 3, and although at any given cross-sectional point along their length, all the ducts 10 will have the same cross-section, the various blocks 9a to 9h of Figure 3 illustrate the cross-section of blocks 9 at different points along their length. Thus, blocks 9c, 9d, 9g, and 9h illustrate the cross-section employed for blocks 9 used at the end of the heat exchanger adjacent the burner 3. Along this section of their length, the blocks 9 have a substantially constant cross-section, over a length of approximately 3 metres. Only 3 large support legs, 36, 37, and 38 are provided in the blocks 9, to support and locate tubes 12. Over the next adjacent section of approximately 3 metres of duct 10, small teeth 40 are provided, between the main support ribs 36, 37, and 38, as shown in the blocks illustrated by references 9f and 9e in Figure 3. The size of these support ribs increases continuously over the central section of duct 10, such that, at a distance of 6 metres from

burner 3, ribs 40 have a height of approximately 2.5 cm. The overall diameter of duct 10 decreases from approximately 34 cm adjacent burner 3, to 27 cm, at a distance of 6 metres from burner 3. Block 9a illustrates the cross-section of blocks 9 at their end remote from burner 3, a distance of approximately 9 metres. At this point, the diameter of duct 10 is approximately 27 cm. Both the change in height of teeth 40, and the change in overall diameter of duct 10, are substantially continuous over at least a portion of the length of duct 10.

Additional ceramic blocks 41 are provided to support the shaped blocks 9a to 9h.

Also illustrated in Figure 1 are various other lines, vessels, and heat exchangers, for example steam drum 45, and transfer line exchanger 46, of a kind conventionally employed in thermal cracking, the function of which need not be explained in detail.

The thermal cracking furnace disclosed above has a number of substantial advantages as compared with conventional thermal cracking furnaces. In conventional furnaces, heat exchange tubes are placed within a large fireblock, and low residence times are achieved by using several small heat exchange tubes, rather than a single large one, so that the surface area to volume ratio increases. However, the use of such heat exchangers, spaced throughout a fireblock, makes is very difficult to obtain even distribution of heat over the pipe surfaces, particularly in view of their small size. This leads to coking rates which are different for the various heat exchangers, and consequently substantial pressure drops.

In the furnace described above, each heat exchanger has its own feedstock supply, and therefore the flow and pressure drop across each heat exchanger can be controlled independently.

Clearly, various other embodiments of the invention are possible, other than those specifically described above, within the scope of the appended claims.

Particularly, in an alternative embodiment of inner duct 11, (not shown) hydrocarbon feedstock and superheated steam are supplied in a single inner lumen.

We have determined that, with the embodiment illustrated, it is possible because of the excellent temperature profile of the reactor, to carry out thermal cracking with reactor inner wall temperature as high as 950°C or more, without thermal failure of the reactor over extended periods. This is significant because at high temperatures such as these, the rate of the chemical reaction which decomposes carbon build-up in the reactor (the so-called "shift reaction") becomes greater than the rate of the chemical reactions which lead to the build-up of carbon. Because the reactor can operate at a temperature above this critical one at which the shift reaction is faster than the carbon formation reaction, it can be operated for long periods without substantial coke formation.

Furthermore the particular design of the cracking furnace in accordance with the invention enables a substantially reduced overall furnace volume to be achieved for a given throughput. For example a throughput which would require a furnace having a volume of 300 m^3 with conventional designs can typically be achieved utilising a furnace in accordance with the invention having a volume of about 25 m^3.

Claims

1. A hydrocarbon cracking furnace (1), comprising at least one cracking reactor (8) having a first tube (14), connected to a feedstock inlet, said tube being open-ended downstream and being disposed substantially coaxially within a second tube (12), connected to an outlet for cracked products and closed proximate and around the open end of said first tube, said first and and second tubes communicating at a first end (15) of the reactor, a burner (3) disposed proximate the said first end of the reactor, and orientated to generate a flow of hot flue gas in a flue gas duct (10) around the second tube, in a direction co-current with the flow of feedstock in an inner duct (11) defined by the annular space between the first and the second tubes, the said first end (15) of the reactor being disposed in the flow of flue gases from the burner (3), and the reactor extending downstream with respect to the flow of flue gases from the said first end.

2. A furnace as claimed in Claim 1, having means (9) defining an outer wall of a flue gas duct (10) to contain said flow of hot flue gas, said means (9) being disposed about said inner duct (11) for heat transfer between the said outer wall and the said duct (11) wherein the cross-sectional area of the flue gas duct (10) is varied and/or the surface area per unit length of the outer wall of the flue gas duct (10) is increased along at least a portion of the length of the flue gas duct (10) to provide in use an inwardly directed radiative heat flux from the said outer wall which varies along the said portion of the length of the flue gas duct (10) in such a way as to compensate for the fall in temperature of flue gas flowing in the flue gas duct (10).

3. A furnace as claimed in Claim 2, wherein the means (9) defining the said outer wall of the

flue gas duct is provided with a plurality of inwardly projecting ribs (30, 40) having a cross-sectional area which increases along the said portion of the length of the flue gas duct (10).

4. A furnace as claimed in Claim 3 wherein the said cross-sectional area increases continuously along the said portion of the length of the flue gas duct (10).

5. A furnace as claimed in any one of the preceding claims, wherein the tube (12) defining the inner duct (11) comprises a pair of coaxial tubes (12, 13), wherein the innermost (13) of the two coaxial tubes is adapted to supply hydrocarbon feedstock to the end (15) of the reactor.

6. A furnace as claimed in any one of Claims 2 to 5 wherein said means (9) defining the outer wall of the flue gas duct comprises a ceramic block.

7. A furnace as claimed in any one of the preceding claims wherein the tube (12) defining the inner duct comprises a metallic tube.

8. A furnace as claimed in any one of Claims 2 to 7 wherein the cross-sectional area of the flue gas duct (10) decreases over the said portion of its length in the direction away from the burner (3).

9. A hydrocarbon cracking method which comprises supplying a feed of a hydrocarbon to be cracked to the feedstock inlet (30) of a furnace as defined in any one of the preceding claims, and generating from the said burner a flow of flue gas in the flue gas duct (10) to heat and thereby crack the hydrocarbon feed.

10. A method as claimed in Claim 9, wherein the furnace is operated so as to maintain the temperature of the second tube (12) substantially constant over at least the portion of its length corresponding to the said portion of the flue gas duct.

Patentansprüche

1. Kohlenwasserstoffkrackofen (1), umfassend wenigstens

   einen Krackreaktor (8) mit einem ersten Rohr (14), das mit einem Einlaßende für Nachschub verbunden ist, wobei das Rohr stromabwärts offen ist und im wesentlichen koaxial innerhalb eines zweiten Rohrs (12) angeordnet ist, und mit einem Auslaßende für die gekrackten Produkte verbunden ist und nahe bei dem ersten Rohr und um das offene Ende des ersten Rohrs herum verschlossen ist, wobei das erste und das zweite Rohr bei einem ersten Ende (15) des Reaktors miteinander in Kontakt stehen,

   einen Brenner (3), der nahe des ersten Endes des Reaktors angeordnet ist und so orientiert ist, daß er einen Strom heißer Abgase in eine Abgasleitung (10), und um das zweite Rohr herum erzeugt, in einer mit dem Strom des Nachschubs in eine innere Leitung (11), die durch den ringförmigen Zwischenraum zwischen dem ersten und zweiten Rohr bestimmt ist, wobei das erste Ende (15) des Reaktors in dem Strom der Abgase des Brenners (3) angeordnet ist, und der Reaktor sich stromabwärts bezüglich des Stroms der Abgase von dem ersten Ende erstreckt.

2. Ofen nach Anspruch 1, der Mittel (9) besitzt, die eine äußere Wand einer Abgasleitung (10) definiert, die den Strom heißer Abgase enthalten soll, wobei das Mittel (9) um die innere Leitung (11) angeordnet ist, zum Wärmetransfer zwischen der äußeren Wand und der Leitung (11), worin der Querschnittsbereich der Abgasleitung (10) variiert wird, und/oder der Oberflächenbereich pro Einheitslänge der Abgasleitung (10) entlang wenigstens eines Teils der Länge der Abgasleitung (10) erhöht wird, um bei Betrieb einen nach innen gerichteten Abstrahlungswärmestrom von der äußeren Wand die entlang des Teils der Länge der Abgasleitung (10) variiert, zu liefern, um Temperaturabfall des in der Abgasleitung (10) strömenden Abgases zu kompensieren.

3. Ofen nach Anspruch 2, worin die Mittel (9), die die äußere Wand der Abgasleitung definieren mit einer Vielzahl von nach innen gerichteter Rippen (30, 40) mit einen Querschnittsbereich zur Verfügung zu stellen, der entlang des Teils der Länge der Abgasleitung ansteigt, versehen sind.

4. Ofen nach Anspruch 3, worin der Querschnittsbereich kontinuierlich entlang des Teils der Länge der Abgasleitung ansteigt.

5. Ofen nach einem der vorhergehenden Ansprüche, worin das Rohr (12), das die innere Leitung (11) definiert ein Paar koaxialer Röhren (12,13) umfasst, worin die innerste (13) der beiden koaxial verlaufenden Röhren zur Lieferung von Kohlenwasserstoffnachschub an das Ende (15) des Reaktors angepasst ist.

6. Ofen nach einem der Ansprüche 2 bis 5, worin die Mittel (9), die die äußere Wand der Abgasleitung definieren einen Keramikblock umfassen.

7. Ofen nach einem der vorhergehenden Ansprüche, worin das Rohr (12), das die innere Leitung definiert ein metallisches Rohr umfaßt.

8. Ofen nach einem der Ansprüche 2 bis 7, worin der Querschnittsbereich der Abgasleitung (10) über den Teil seiner Länge in der Richtung weg vom Brenner (3) abnimmt.

9. Kohlenwasserstoffkrackverfahren, umfassend Versorgen mit einem Strom von zu krackendem Kohlenwasserstoff in die Nachschubeinlaßöffnung (30) eines Ofens wie in einem der vorhergehenden Ansprüche definiert, und von dem Brenner einen Strom Abgas in die Abgasleitung (10) zu erzeugen und dabei den Kohlenwasserstoffstrom zu kracken.

10. Verfahren nach Anspruch 9, worin der Ofen so betrieben wird, daß die Temperatur des zweiten Rohrs (12) im wesentlichen über wenigstens einen Teil seiner Länge, korrespondierend zu dem Teil der Abgasleitung konstant gehalten wird.

Revendications

1. Un four (1) de craquage d'hydrocarbure, comprenant au moins un réacteur de craquage (8) comportant un premier tube (14), relié à une entrée de matière première, ledit tube ayant une extrémité aval ouverte et étant disposé de façon sensiblement coaxiale à l'intérieur d'un deuxième tube (12), relié à une sortie pour les produits de craquage et à proximité immédiate et autour de l'extrémité ouverte dudit premier tube, lesdits premier et deuxième tubes communiquant à une première extrémité (15) du réacteur, un brûleur (3) situé à proximité de ladite première extrémité du réacteur, et orienté de façon à générer un flux de gaz de fumée chaud dans un conduit de gaz de fumée (10) autour du deuxième tube, dans une direction de même sens que celle du flux de matière première dans un conduit interne (11) défini par l'espace annulaire compris entre le premier et le deuxième second tubes, ladite première extrémité (15) du réacteur étant placée dans le flux des gaz de fumée en provenant du brûleur (3), et le réacteur s'étendant en aval relativement à l'écoulement des gaz de fumée de ladite première extrémité.

2. Un four conforme à la revendication 1, comportant un moyen (9) qui définit une paroi externe d'un conduit de gaz de fumée (10) pour contenir ledit écoulement du gaz de fumée chaud, ledit moyen (9) étant situé autour dudit conduit interne (11) pour permettre le transfert de chaleur entre ladite paroi externe et ledit conduit (11) dans lequel la surface de la section transversale du conduit de gaz de fumée (10) varie et/ou la surface par unité de longueur de la paroi externe du conduit de gaz de fumée (10) augmente sur au moins une partie de la longueur du conduit de gaz de fumée (10) pour permettre en cours d'utilisation un flux de chaleur par radiation dirigé vers l'intérieur à partir de ladite paroi externe qui varie le long de ladite partie de la longueur du conduit de gaz de fumée (10) de façon à compenser la chute de température du gaz de fumée qui s'écoule dans le conduit de gaz de fumée (10).

3. Un four conforme à la revendication 2, dans lequel le moyen (9) définissant ladite paroi externe du conduit de gaz de fumée comporte une pluralité de nervures (30, 40) faisant saillie vers l'intérieur et ayant une surface en coupe transversale qui augmente le long de ladite portion de la longueur du conduit de gaz de fumée (10).

4. Un four conforme à la revendication 3, dans lequel ladite surface en coupe transversale augmente continûment le long de ladite partie de la longueur du conduit de gaz de fumée (10).

5. Un four conforme à l'une quelconque des revendications précédentes, dans lequel le tube (12) qui définit le conduit interne (11) consiste en une paire de tubes coaxiaux (12, 13), dans lequel le plus interne (13) des deux tubes coaxiaux est apte à fournir la matière première hydrocarbure à l'extrémité (15) du réacteur.

6. Un four conforme à l'une quelconque des revendications 2 à 5, dans lequel ledit moyen (9) définissant la paroi externe du conduit de gaz de fumée consiste en un bloc de céramique.

7. Un four conforme à l'une quelconque des revendications précédentes, dans lequel le tube (12) définissant le conduit interne consiste en un tube métallique.

8. Un four conforme à l'une quelconque des revendications 2 à 7, dans lequel la surface en coupe transversale du conduit de gaz de fu-

mée (10) diminue sur ladite portion de sa longueur en s'éloignant du brûleur (3).

9. Un procédé de craquage d'hydrocarbure, qui consiste à envoyer une alimentation en hydrocarbure que l'on doit craquer à l'entrée de matière première (30) d'un four tel que défini dans l'une quelconque des revendications précédentes, et à générer à partir dudit brûleur un écoulement de gaz de fumée dans le conduit de gaz de fumée (10) pour chauffer et par là craquer la matière première hydrocarbure.

10. Un procédé conforme à la revendication 9, dans lequel le four fonctionne de façon à maintenir la température du deuxième tube (12) sensiblement constante sur au moins une partie de sa longueur correspondant à ladite partie du conduit de gaz de fumée.

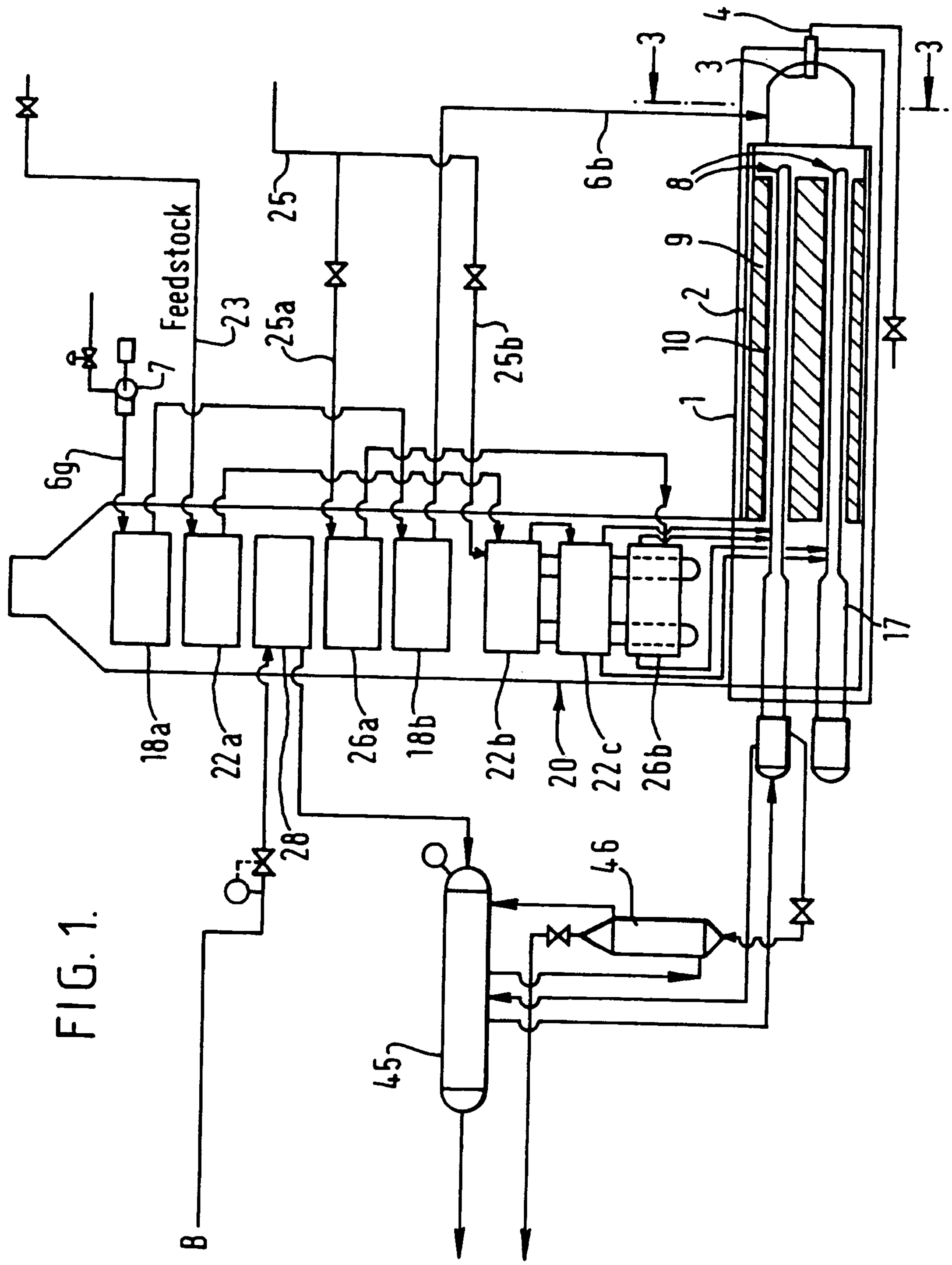
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FIG. 1.

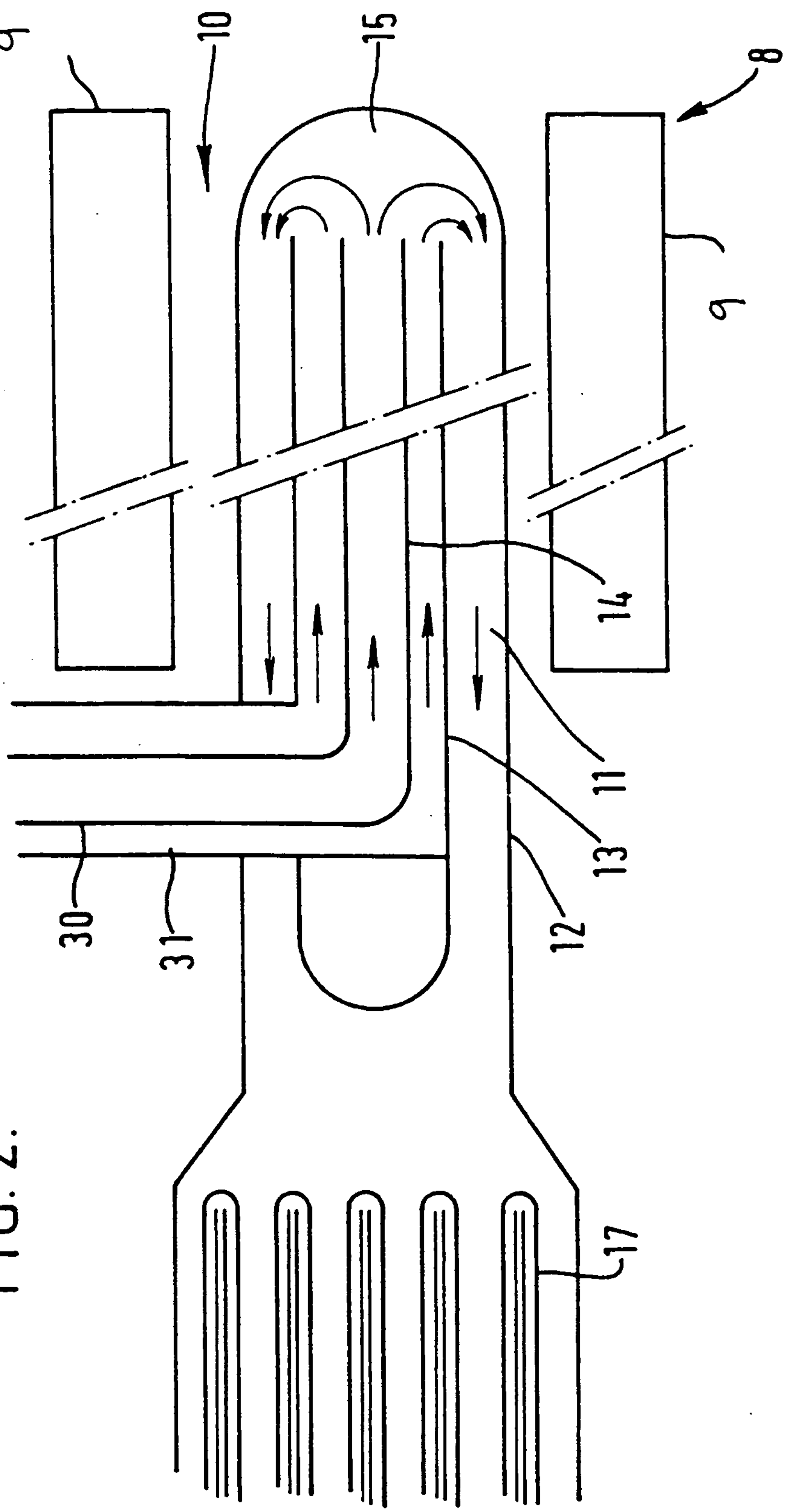

FIG. 2.

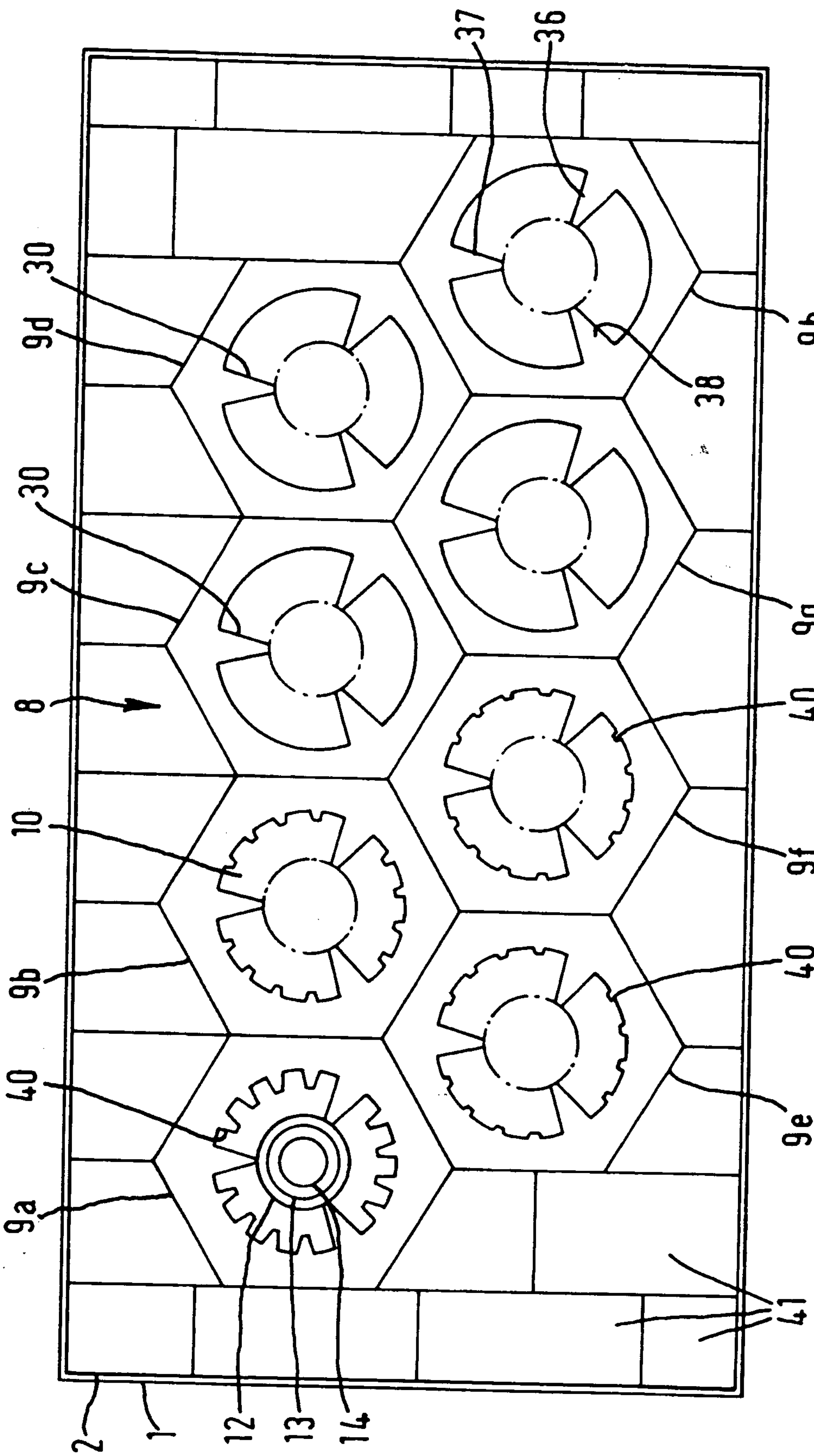

FIG. 3.